

CHAPTER 3

QUALITY SURVEILLANCE

This chapter will cover characteristics of fuels and quality surveillance. The fuels that the ABF will most commonly work with at naval activities are automotive gasoline (MOGAS) and jet engine (JP) fuels. You need to know the basic characteristics of these fuels to understand the need for safety and caution in handling them. This chapter includes the basic characteristics of gasolines and jet engine fuels that fuel-handling personnel should know.

CHARACTERISTICS AND PROPERTIES OF FUELS

LEARNING OBJECTIVE: Describe the characteristics and properties of the fuels commonly handled by the ABF.

Motor gasolines and jet engine fuels are petroleum products manufactured from crude oil by oil refineries. Through distillation, the crude oil is separated into **fractions**, which are groups of compounds having boiling points within a given range. Nearly all of the distillate fractions may be used as fuels. These fractions (which include gasoline, kerosene, jet fuels, and diesel fuel) are known as distillate fuels.

Distillate fuels are flammable liquids. This means they burn when ignited. Under proper conditions they even explode with forces similar to those of TNT or dynamite. Death can result if the vapors of any of these fuels are inhaled in sufficient quantities. Serious skin irritation also can result from contact with the fuels in the liquid state.

In the liquid form petroleum fuels are lighter than water, and in the vapor form they are heavier than air. So any water present in these fuels usually settles to the bottom of the container. On the other hand, vapors of these fuels, when released in the air, also tend to remain close to the ground. This increases the danger to personnel and property. From safety and health standpoints, motor gasolines and jet engine fuels must be handled with caution.

SOURCE OF ENERGY

Petroleum fuel is a liquid containing heat energy that turns into mechanical energy in an engine. An engine fuel must be made to suit the engine in which it is to be used. In the case of the aircraft engine, the fuel must also be suitable for the aircraft under a wide variety of operating conditions. There is no such thing as a universal fuel since a fuel suited for a gasoline engine does not work in a diesel engine and vice versa.

MOGAS DESCRIPTION

MOGAS (NATO Code Number F-46) is a gasoline composed of a mixture of highly volatile liquid hydrocarbons designed for use in internal combustion engines. It is composed of the lower boiling elements of petroleum and is **explosive and volatile, and must be handled with extreme caution.**

The octane number of MOGAS is

Motor – 83

Research – 91

The octane number is a numerical measure of the antiknock properties of motor fuel, based on the percentage of volume of isooctane in a standard reference fuel. For example, a motor fuel that produces the same degree of knocking as a standard reference fuel containing 80 percent isooctane has an octane number of 80. Octane number also may be referred to as octane rating. Because MOGAS has a low octane rating, it may cause knocking in engines.

JP-5 DESCRIPTION

JP-5 (NATO Code Number F-44) is best described as a kerosene-type jet fuel. It was developed to provide a higher flash-point fuel that could be stored on board more safely than either gasoline or earlier jet fuels. Like gasoline, it is a mixture of liquid hydrocarbons produced from petroleum. However, JP-5 is composed of higher boiling components than gasoline and is not as explosive and volatile as gasoline. JP-5 is the only grade of jet fuel authorized for fueling aircraft on Navy ships.

Although JP-5 does have a high flash point (140°F minimum) when manufactured, if it is mixed with other fuels that have a lower flash point, the liquid becomes unsafe. Even with its high flash point, JP-5 is highly flammable on rags and clothing, which act as a wick.

JP-5 is also an acceptable substitute for fuel, naval distillate, F-76 (commonly known as DFM), for use in diesels, gas turbines, and boilers.

JP-4 DESCRIPTION

JP-4 (NATO Code Number F-40) is a wide-cut gasoline-type jet fuel having a low flash point, typically below 10°F (-17.8°C). It is used by the Air Force, Army, and some Navy shore stations. It is **volatile, flammable, and dangerous**. JP-4 mixed with JP-5 will lower the JP-5 flash point to an unacceptable level for shipboard use.

JP-8 DESCRIPTION

JP-8 (NATO Code Number F-34) is a kerosene-type jet fuel having a flash point of 100°F (37.8°C). It is used by the Air Force in Europe and the British Isles, rather than JP-4. JP-8 mixed with JP-5 also will lower the flash point of the JP-5 to an unacceptable level for shipboard use.

VOLATILITY

The volatility of a petroleum fuel is usually measured in terms of vapor pressure and distillation. The vapor pressure indicates the tendency toward vaporization at specific temperatures, while distillation provides a measure of the extent to which vaporization proceeds at a series of temperatures.

Vapor pressure is measured in a Reid vapor pressure test bomb. In the test, one volume of fuel and four volumes of air are contained in a sealed bomb fitted with a pressure gage. The container and fuel are heated to 100°F, shaken, and the pressure read on the gage. The pressure shown on the gage is known as the Reid vapor pressure (RVP) and is expressed in pounds per square inch (psi).

The measurement for volatility by distillation is done in a standard distillation apparatus. The fuel in this test is heated to given temperatures with an amount of fuel boiled off as each temperature is measured. The military specification for the fuel gives these temperatures and the percentages of the fuel allowed to boil off to meet the desired standard.

Any fuel must vaporize and the vapor be mixed in a given percentage of air for it to burn or explode. For gasoline vapors in air, the limits are approximately a minimum of 1 percent and a maximum of 6 percent by volume. Other types of fuel vapors may have different limits.

Volatility is an important factor in the proper operation of internal-combustion piston engines. In a piston engine, the fuel must vaporize and be mixed with a correct volume of air to burn and deliver power. If part of the fuel does not vaporize, it is wasted. Furthermore, it can damage the engine by washing the lubricant from the engine cylinder walls, which causes rapid wear to the piston rings and cylinder walls.

Military jet fuels in use at the present by the Navy include JP-4, which has a vapor pressure of 2 to 3 psi. and JP-5, which has no specification for vapor pressure. The vapor pressure for JP-5 is almost 0 psi at normal room temperatures and at standard atmospheric pressure.

Gasoline has a very strong tendency to vaporize and, as a result, always has considerable vapors mixed with the air over the surface of the liquid. In fact, in a closed tank at sea level with temperatures approximately 10°F or higher, so much fuel vapor is given off by gasoline that the fuel-air mixture is too rich to burn. When fuel is in contact with air, the fuel continues to evaporate until the air is saturated.

The amount of fuel vapor in the air above a fuel can never be greater than the saturation value. Of course, it takes time to saturate the air with fuel vapor, so the actual percentage of fuel vapor may be considerably below the saturation point, especially if the fuel container is open to air circulation.

JP-5 fuel does not give off enough vapor to be explosive until it is heated considerably above 100°F. However, if the JP-5 fuel is contaminated with even a small amount of gasoline or, more likely, JP-4, the amount of vapor given off increases to the point where it is in the flammable range at a much lower temperature. At room temperatures, 0.1 percent gasoline or JP-4 in JP-5 results in a fuel that is unsafe to store aboard ship since it fails the flash point requirement for unprotected storage.

Because of the range of its vapor pressure, grade JP-4 forms explosive vapors from minus 10°F to plus 80°F, its normal storage and handling temperatures. **This means that the space above the liquid almost always contains an explosive mixture.**

SPECIFIC GRAVITY

The specific gravity is the ratio of the weight of a given volume of a fuel to the weight of an equal volume of distilled water. Normally, the gravity of petroleum products is converted to degrees API, according to the API (American Petroleum Institute) scale. All gravity determinations are correlated with a specific temperature of 60°F by use of ASTM Standard D1250-80.

The specific gravity of petroleum products must be determined to correct the volume at different temperatures when gauging the liquid content of storage tanks, tankers, and barges. The specific gravity of JP-5 is also used to select the proper discharge ring on the centrifugal purifier.

A change of the specific gravity of a fuel may indicate a change of composition caused by the mixing of different fuels, or even mixing different grades of the same fuel.

VISCOSITY

Viscosity is the measure of a liquid's resistance to flow. The significance of viscosity depends on the intended use of the product. For application and performance, proper viscosity is highly important since specified minimum and maximum flow rates of flow are required for all fuels and lubricating oils. In fuel, viscosity determination serves as an index of how it will flow to the burners, the extent to which it will be atomized, and the temperatures at which the fuel must be maintained to be properly atomized.

SOLVENCY OF FUELS

All petroleum fuels have the characteristic of being able to dissolve some materials. They can dissolve common lubricants, such as oils and greases in pumps, valves, packing, and other equipment. This characteristic requires the use of special lubricants for gasoline services.

Gasolines also cause serious deterioration of all rubber materials except those synthetic types designed especially for gasoline service. It is very important, therefore, that only hose specially made and designated for gasoline be used in this service. This also applies to packing, gaskets, and other materials that must be used in gasoline systems.

Like gasoline, jet engine fuels have certain solvent properties that dissolve greases and cause deterioration of some rubber materials. Therefore, only specially designated greases and synthetic materials should be used for jet engine fuel service. Another important solvent property of jet engine fuels is their ability to dissolve asphalt used for aircraft runways

and pavements. Jet engine fuels seriously damage asphalt pavements, and even small spills of this fuel on asphalt pavement should be avoided.

FREEZING POINTS OF FUELS

The freezing point of a fuel is the temperature at which solid particles begin to form in the fuel. These particles are waxy crystals normally held in solution in the fuel. These particles can readily block the filters in an aircraft fuel system. The fuel almost always becomes cloudy before the solid particles form. This cloud is due to the presence of dissolved water in the fuel coming out of the solution and freezing.

The freezing point of JP-5 is - 51°F. The fuels used by other NATO countries and by commercial users vary widely.

FLASH POINTS OF FUELS

The flash point of a fuel is the lowest temperature at which the fuel vaporizes enough to form a combustible vapor. These temperatures vary according to the fuel in question.

The flash point of a fuel is an index of the fuel's potential safety when being handled or when in storage. JP-5 must have a flash point of at least 140°F to have the high safety factor required for storage aboard an aircraft carrier in unprotected tanks. F-40 (JP-4) and F-34 (JP-8) fuels flash at any normal temperature and are in danger of ignition any time they contact a hot surface. Therefore, these fuels must be handled with caution from a safety standpoint.

HEALTH HAZARDS OF AVIATION FUELS

Most people are aware of the explosive and fire potential of aviation fuels. Furthermore, there is a danger to the health of the individual who must work where hydrocarbon vapors are present. Prolonged inhalation of hydrocarbon vapors can cause dizziness, intoxication, nausea, and death. Consequently, approved safety procedures that minimize the dangers to the health of fuel-handling personnel must be followed meticulously.

Gasoline

The concentration of gasoline vapors that can be tolerated by man is far below that required to produce combustible or explosive mixtures with air. Even one-tenth of the amount necessary to support combustion or to form an explosive mixture is harmful if inhaled for more than a short time, causing dizziness, nausea, and

headache. Large amounts act as an anesthetic causing unconsciousness or death.

Personnel should not be permitted to work in spaces where hydrocarbon vapor concentrations exceed 500 parts per million by volume, unless they are protected by an air-supplied respirator. It is recommended that personnel be permitted to work only in well-ventilated spaces where the hydrocarbon vapors are at or below the permissible limit.

The occurrence of any of the symptoms mentioned, among personnel who are handling gasoline or who are within an area in which gasoline is handled or spilled, should be taken as a warning of the presence of dangerous amounts of gasoline vapor in the air. All exposed personnel must be sent out of the area until the vapors have been cleared. Recovery from early symptoms is usually prompt after removal to fresh air. Anyone who is overcome should be given first aid at once. Medical attention should be obtained promptly. First aid includes removing gasoline from the skin (if the skin or clothing has been contaminated in a fall or other accident), preventing chilling, and applying artificial respiration if breathing has ceased.

Tetraethyl lead, which was added to increase the antiknock value of gasoline, is no longer used, **but it could remain impregnated in tanks or piping systems.** The lead compound may enter the body through inhalation, by absorption through the skin, and by the mouth. Also, the gasoline vapor itself, when inhaled, may result in sickness. Therefore, take the following precautions:

- Avoid contact with liquid gasoline.
- Do not inhale gasoline vapors.
- Do not enter tanks that have contained gasoline until all traces of gasoline vapors have been eliminated.

NOTE

Sediment and sludge impregnated with gasoline may be present at the bottom of the tank. These constitute a serious fire and poison hazard until the tank is thoroughly cleaned. Before you enter the gasoline storage tanks, you must obtain permission from the commanding officer, and the gas-free engineer must test and certify the tanks are safe for entry.

There is danger in entering a tank that has been used for the storage of gasoline because of the chance of exposure to the toxic concentration of gasoline vapors in the air and in the sludge, wet or dry, in the bottom of

such tanks. No person should be permitted to enter such a tank without special equipment and complete instructions for its use.

Gasoline is exceedingly irritating when swallowed. If gasoline should be swallowed, accepted first aid procedures must be followed and medical attention obtained as soon as possible.

Gasoline causes severe burns if it is allowed to remain in contact with the skin, particularly when the contact is maintained under soaked clothing or gloves. Clothing or shoes having gasoline on them should be removed at once. Repeated contact with gasoline removes the protective oils from the skin and produces drying, roughness, chapping, and cracking. Skin infection may follow this damage to the skin. A severe skin irritation may develop, beginning usually on the hands and perhaps extending to other parts of the body.

As soon as possible after contact, gasoline should be removed from the skin, preferably by washing with soap and water. Rags or waste, wet with gasoline, must not be put in a pocket, but must be disposed of at once. Soaked clothing should be kept away from flames or sparks, and should be washed out thoroughly with soap and water as soon as possible. If gasoline comes in contact with the eyes, accepted first aid procedures must be given at once.

Jet Fuels

Jet fuels may contain more toxic aromatics than gasolines. They should, therefore, be handled with the same health precautions as apply to gasolines. They should not be used for cleaning. The hygienic or health aspects for gasoline, therefore, apply equally well to jet fuels. These include precautions covering particularly the inhalation of vapors, skin irritations, and container hazards.

An important step in preventing the buildup of fuel vapors is to operate the ventilation system provided for all spaces where fuels are handled. The aviation fuels security watch must monitor the ventilation in these spaces when they are not manned. Vapor buildup due to inoperative ventilation is dangerous to both you and your ship. Notify your supervisor immediately if you discover the ventilation system in one of your fuels spaces is not working.

The *Standard First Aid Training Course*, NAV-EDTRA 12081, should be studied by all personnel working with fuels for information on the treatment of those overcome or injured when handling fuels.

SUMMARY OF CHARACTERISTICS OF FUELS

In summary, it is important that you remember the following characteristics of fuels:

—From the standpoint of fire, explosion, and health, gasolines, JP-4, and JP-8 are extremely hazardous and must be handled with equal caution. JP-5 jet fuel is safer, with respect to possible explosions and poisoning. However, the potential hazards of fire from fuel-soaked rags and waste and of skin blistering from soaked clothing must not be ignored.

—Jet engine fuels and gasolines are designed for entirely different types of engines. Therefore, the proper fuel must be used for each type of engine.

QUALITY SURVEILLANCE

LEARNING OBJECTIVES: Describe the problems caused by fuel contamination. State the types and limits of fuel contaminants. Describe the equipment used and explain the correct operating procedures in testing for fuel contamination.

The major objective of fuel-handling personnel is to deliver fuel to aircraft, clean and free of water. The complex fuel systems of modern aircraft do not function properly if the fuel is contaminated with dirt, rust, water, or other foreign matter. Even very small quantities of dirt or solid matter can plug or restrict fuel metering orifices and accelerate the clogging of fuel filters. Very small quantities of water are also harmful since ice may form in aircraft tanks at high altitudes. Ice affects orifices, controls, and filters like dirt. The complete stoppage of fuel flow by ice or dirt causes engine failure, and partial stoppage causes poor engine performance.

PROBLEMS CAUSED BY FUEL CONTAMINATION

Contaminated fuel has caused aircraft accidents with a tragic loss of life, loss of valuable aircraft, and the grounding of entire squadrons. This means that clean fuel is a LIFE-OR-DEATH matter with aviation personnel. The lesson has been learned the hard way by too many, and with fatal results. The time to become fuel conscious is NOW.

ENGINE FAILURES

Besides being deadly, contaminants can be sneaky. A certain type of emulsion resulting from the presence of water and rust particles can stick to the sides of an aircraft's fuel cells and not be noticed. You can even drain out a sample of fuel and find no evidence of this deposit. It can continue to build up and part of it may wash off and pass through a strainer into a fuel control. There can be only one result, reduced power and, finally, engine failure.

Foreign particles so small they cannot be seen with the naked eye can cause damage in a jet engine. The fuel control of a jet engine is a masterpiece of engineering and craftsmanship. It automatically regulates fuel flow to compensate for changes in altitude and speed. It makes practical the piloting by human beings of incredibly powerful jet aircraft. But doing these things requires that the fuel control have precisely fitted meters and valves. The moving parts within some of these meters and valves have clearances of less than 0.005 of an inch. Particles of foreign matter only slightly larger than this clearance can jam the valve or prevent it from seating properly. Particles slightly smaller can stick and build up, or wedge between the parts. Thus, we must remove particles so small they can be seen only with a microscope.

UNNECESSARY REPAIR WORK

Fuel carrying water or dirt can cause a great deal of extra maintenance work. For example, in atypical Navy engine overhaul shop it became necessary at one time to completely disassemble every jet engine fuel control that came into the shop because of the chance of internal damage. Ordinarily, the controls that had been in use less than half of their overhaul time could have simply been bench-checked to verify their performance and then returned for use on the engine. However, experience showed that more than 50 percent of the fuel controls overhauled had failed because of internal corrosion. The cause was water in the fuel. Such extra repair work is not confined to jet engines. Water in the fuel also can cause erroneous readings on the aircraft's fuel quantity gages, which can be exceedingly dangerous in flight.

DELAYED FLIGHTS

In addition to causing engine failures, fuel contamination can mean serious delays in flight operations. Normal procedure requires that all aircraft fueled from a source where contamination is discovered be checked.

In some cases, aircraft must be defueled and then refueled before flight operations can proceed.

When a fuel is found to be contaminated, the contaminant must be tracked back to its source and the cause corrected. Until the cause of the contamination is found and corrected, the contaminated system cannot be used. The fuel system may be a mobile refueler, air station hydrant refueling system, or the entire fuels system of an aircraft carrier. Contaminated fuel may affect the operation of one aircraft or the operation of an entire air wing. For these reasons, be careful in every phase of fuel handling to prevent contaminants from entering the fuel.

CAUSES OF FUEL CONTAMINATION

How can you find out the causes of fuel contamination? How can you find out how much contamination is too much? Before you can determine amounts of contamination, you have to be able to understand the units of measurement used to identify contamination. The two major units for measuring the size of contaminants are microns for solids and parts per million (ppm) for water.

There are approximately 25,400 microns in 1 inch. Figure 3-1 gives you a microscopic view of a human hair, which is about 100 microns in diameter, and compares it with a 5-micron contaminant.

Parts per million is the reference used for water contamination. If you take a 32-oz sample bottle and fill it 3 1/4 inches from the bottom, the amount you will have is about 500 milliliters (ml). Break that 500 ml down into one million little pieces. You now have 1 ppm.

As you now realize, the equipment used in the quality surveillance laboratory has to be very accurate to make measurements that small. Operation of the lab equipment will be covered later in this chapter.

HUMAN FACTOR

Equipment now in use can remove most of the contamination that may be present in a fuel. It cannot separate two mixed or blended fuels. It cannot effectively reduce the contamination below the required limits if the contaminant level is too high. YOU must be careful to prevent the introduction of contamination in all phases of fuel handling. Additionally, all steps of contamination removal MUST be properly performed.

Inspection and sampling procedures are the only means to ensure that the equipment is performing properly. Unless the equipment is properly operated and the sampling procedures are carefully followed, the problem will always remain. Thus, the most important factor in preventing and removing contamination in fuels is the awareness of the people who handle the fuel.

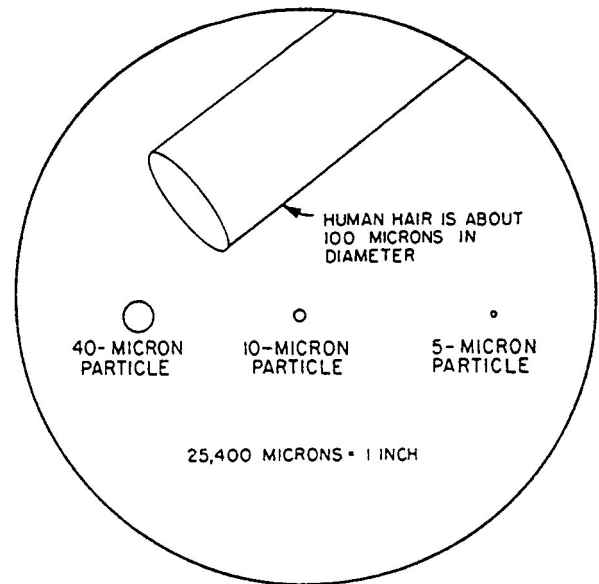


Figure 3-1.—Enlargement of small particles and comparison to a human hair.

The equipment is only a machine. You, the ABF, the educated operator, make a quality surveillance program work.

LIMITS OF CONTAMINATION

To be acceptable for delivery to aircraft, jet fuels must be clean and bright. They must not contain more than 5 ppm free water or 2 mg/liter particulate contamination. The terms *clean* and *bright* have no relation to the natural color of the fuel. Jet fuels are not dyed and they vary from clear, water-white to straw-yellow colored. *Clean* means the absence of any cloud, emulsion, visible sediment, or free water. *Bright*, means the fuel has a shiny, sparkling appearance.

A cloud, haze, specks of particulate matter, or entrained water indicate that the fuel is unsuitable and point to a probable breakdown in fuel handling equipment or procedures. If contamination limits are exceeded, delivery of fuel to aircraft shall be stopped and corrective measures completed before resuming fueling operations.

CAUSES OF CONTAMINATION

Steps should be taken to find the source of trouble and corrective measures taken immediately. See figure 3-2 for the various types of contamination that may be detected visually. The first sample of fuel in this illustration is an acceptable fuel.

Water

Water in fuels may be either fresh or salt and may be present either as dissolved or free water. Dissolved

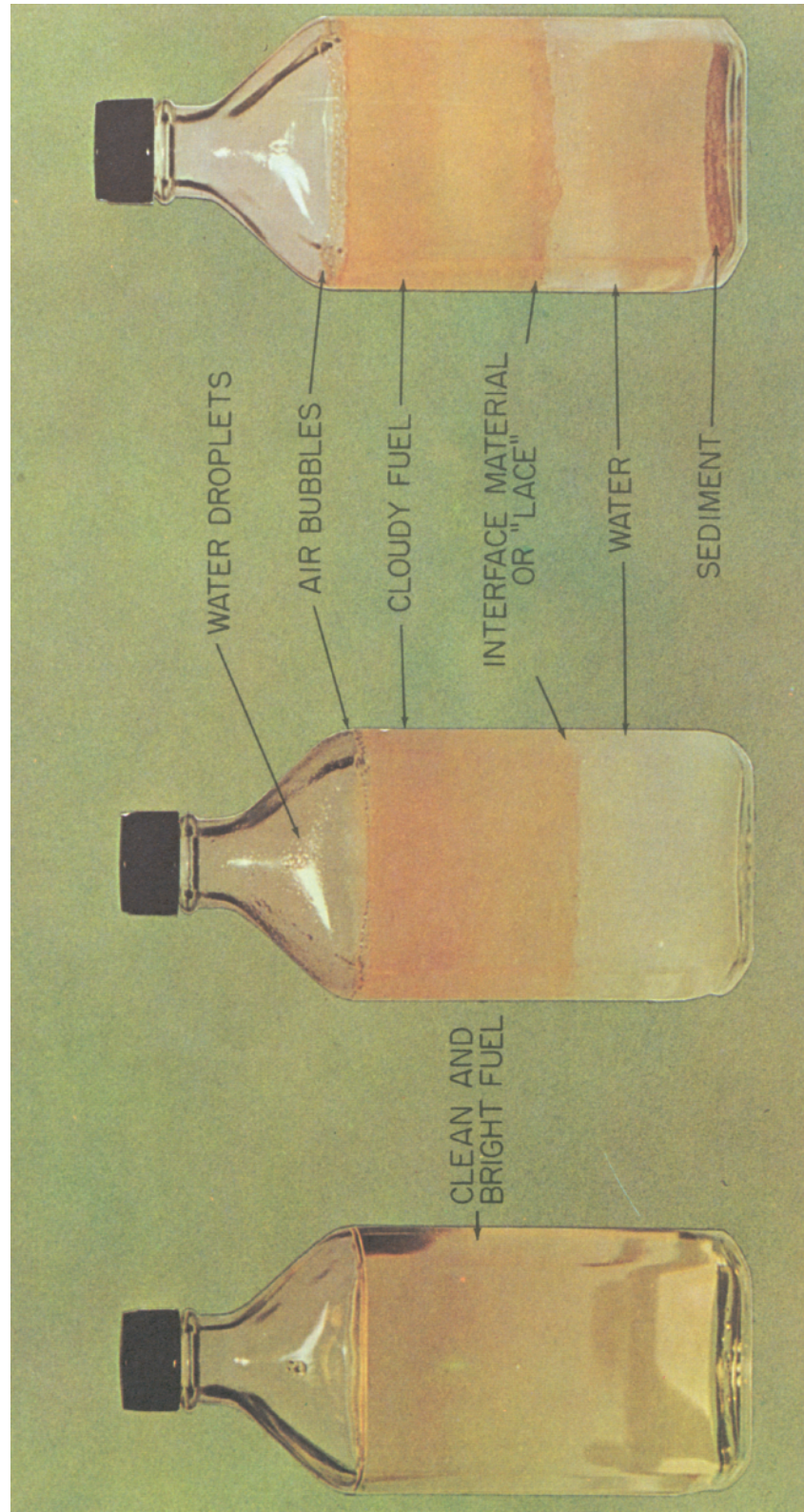


Figure 3-2.—Samples of JP-5 showing common types of visually detected contamination. (The air bubbles are not contaminants and are shown for information only.)

water is water absorbed in the fuel and is NOT visible. Free water may be in the form of a cloud, emulsion, droplets, or in gross amounts in the bottom of a tank or container. (Entrained water is free water that has not settled to the bottom.) Any form of free water can cause icing in the aircraft fuel system, malfunctioning of fuel quantity probes, and corrosion of fuel system components. Salt water will promote corrosion more rapidly than fresh water.

Ordinarily, a cloud indicates water-contaminated fuel. Occasionally, a cloud indicates excessive amounts of fine sediment or finely dispersed stabilized emulsion. Fuel containing a cloud from either cause is not acceptable. When clean and bright fuel cools, a cloud may form, indicating that dissolved water has precipitated out. This precipitation cloud represents a very slight amount of fresh water. This cloud appears when warm fuel is pumped to a cool area where the sample is taken. Remember, even though this is a very slight amount of water, if the fuel is not clear and bright, it does not go into an aircraft.

Sediment

Sediment appears as dust, powder, fibrous material, grains, flakes, or stain. Specks or granules of sediment indicate particles in the visible size (approximately 40 microns or larger). See figure 3-1. The presence of any appreciable number of such particles indicates a malfunction of the filter/separators, a source of contamination downstream of the filter/ separators, or an improperly cleaned sample container. Even with the most efficient filter/separators and careful fuel handling, an occasional particle may be seen. These strays are usually due to particle migration through the filter media and may present no particular problem to the engine or fuel control. The sediment ordinarily encountered is an extremely fine powder, rouge, or silt. The two principal components of this fine sediment are normally sand and rust.

Sediment includes both organic and inorganic matter. The presence of large quantities of fibrous materials (close to naked eye visibility) is usually indicative of filter element breakdown, either because of a ruptured element or mechanical disintegration of a component in the system. Usually, high metal content of relatively large particles suggests a mechanical failure somewhere in the system, which is not necessarily limited to a metallic filter failure.

In a clean sample of fuel, sediment should not be visible except upon the most meticulous inspection. Persistent presence of sediment is suspect and requires

that appropriate surveillance tests and corrective measures be applied to the fuel-handling system.

Sediment or solid contamination can be separated into two categories:

1. Coarse sediment
2. Fine sediment

Coarse sediment is sediment that can be seen and that easily settles out of fuel or can be removed by adequate filtration. Ordinarily, particles 10 microns and larger are regarded as coarse sediment. See table 3-1 for more information. Coarse particles clog orifices and wedge in sliding valve clearances and shoulders, causing malfunctions and excessive wear of fuel controls and metering equipment. They also can clog nozzle screens and other fine screens throughout the aircraft fuel system.

Fine sediment consists of particles smaller than 10 microns in size. Proper settling, filtration, and centrifuging can remove 98 percent of the fine sediment in fuel. Particles in this range accumulate throughout fuel controls. They appear as a dark shellac like surface on sliding valves. They also may be centrifuged out in rotating chambers as sludgelike matter that causes sluggish operation of fuel-metering equipment. Fine particles are not visible to the naked eye as distinct or separate particles. However, they scatter light and may appear as point flashes of light or a slight haze in fuel.

Maximum settling time should be allowed in fuel tanks after they are filled to allow reasonable settlement of water and sediment. This can be done by proper rotation of the fuels.

Microbiological Growth

Microbiological growth consists of living organisms that grow at a fuel/water interface. These organisms include protozoa, fungus, and bacteria. Fungus is the major constituent and the cause of most problems associated with microbiological contamination of jet fuels. Fungus is a vegetable life; it holds rust and water in suspension and is an effective stabilizing agent for fuel-water emulsion. It clings to glass and metal surfaces and can cause erroneous readings in fuel quantity systems, sluggish fuel control operation, and sticking flow dividers. Microbiological growth is generally found wherever pockets of water exist in fuel tanks. It usually has a brown, black, or gray color and a stringy, fibrouslike appearance.

For microorganisms to develop in jet fuels, free water must be present. Traces of metallic elements are also necessary, but water is the key ingredient. Without

Table 3-1.—Visual Contamination Table

TYPE CONTAMINANTS	APPEARANCE	CHARACTERISTICS	EFFECTS ON AIRCRAFT	ACCEPTABILITY LIMITS FOR DELIVERY TO AIRCRAFT
A. WATER				
(1) Dissolved Water	Not visible.	Fresh water only. Precipitates out as cloud when fuel is cooled.	None unless precipitated out by cooling of fuel. Can then cause ice to form on low pressure fuel filters if fuel temperature is below freezing.	Any amount up to saturation.
(2) Free Water	Light cloud. Heavy cloud. Droplets adhering to sides of bottle. Gross amounts settled in bottom.	Free water may be saline water or fresh water. Cloud usually indicates water-in-fuel emulsion.	Icing of fuel system-usually low pressure fuel filters. Erratic fuel gage readings. Gross amounts of water can cause flame-outs. Salt water will cause corrosion of fuel system components.	Zero-Fuel must contain no visually detectable free water.
B. PARTICULATE MATTER				
(1) Rust	Red or black powder, rouge, or grains. May appear as dye-like material in fuel.	Red rust (Fe ₂ O ₃)-nonmagnetic. Black rust (Fe ₃ O ₄)-magnetic. Rust generally comprises major constituent of particulate matter.	Will cause sticking, and sluggish or general malfunction of fuel controls, flow dividers, pumps, nozzles, etc.	*Refer to NOTE 1
(2) Sand or Dust	Crystalline, granular or glass-like.	Usually present and occasionally constitutes major constituent.	Will cause sticking, and sluggish or malfunction of fuel controls, flow dividers, pumps, nozzles, etc.	*Refer to NOTE 1
(3) Aluminum or Magnesium Compounds	White or gray powder or paste.	Sometimes very sticky or gelatinous when wet with water. Usually present and occasionally represents major constituent.	Will cause sticking, and sluggish or general malfunction of fuel controls, flow dividers, pumps, nozzles, etc.	*Refer to NOTE 1
C. MICROBIOLOGICAL GROWTH	Brown, gray, or black. Stringy or fibrous.	Usually found with other contaminants in the fuel. Very light weight; floats or "swims" in fuel longer than water droplets or solid particles. Develops only when free water is present.	Fouls fuel quantity probes, sticks flow dividers, makes fuel controls sluggish.	Zero.
D. EMULSIONS				
(1) Water-in-fuel Emulsions	Light cloud. Heavy cloud.	Finely divided drops of water in fuel. Same as free water cloud. Will settle to bottom in minutes, hours, or weeks depending upon nature of emulsion.	Same as free water.	Zero-Fuel must contain no visually detectable free water.
(2) Fuel and Water or "Stabilized" Emulsions	Reddish, brownish, grayish, or blackish. Sticky material variously described as gelatinous, gummy, like catsup, or like mayonnaise.	Finely divided drops of fuel in water. Contains rust or microbiological growth which stabilizes or "firms" the emulsion. Will adhere to many materials normally in contact with fuels. Usually present as "globules" or stringy, fibrouslike material in clear or cloudy fuel. Will stand from days to months without separating. This material contains half to three-fourths water, a small amount of fine rust or microbiological growth and is one third to one half fuel.	Same as free water and sediment, only more drastic. Will quickly cause filter plugging and erratic readings in fuel quantity probes.	Zero.
E. MISCELLANEOUS				
(1) Interface Material	Lacy bubbles or scum at interface between fuel and water. Sometimes resembles jellyfish.	Extremely complicated chemically. Occurs only when emulsion and free water is present.	Same as microbiological growth	Zero-There should be no free water.
(2) Air Bubbles	Cloud in fuel.	Disperses upward within a few seconds.		Any amount.

***NOTE 1:**

Particles large enough to be visible should rarely be present. At the most, the total sediment should be a spot of silt. If any appreciable contamination is found, the test must be repeated. When testing with the AEL Mk III the max is 2mg/l.

water there is no growth. Remove any free water and growth ceases.

Microorganisms in jet fuel can cause severe corrosion damage to metal aircraft fuel tanks. Organic acids, or other byproducts produced by the growth of fungi or bacteria, react chemically with certain matter contained within the fuel to penetrate tank coatings. Once the coating is penetrated, the metal tank is attacked.

Microbiological growth causes fouling of aircraft fuel system filters and erratic operation of fuel-quantity probes. Microbiological contamination is more prevalent in tropical and semitropical climates because of the more favorable temperature and higher humidity. The presence of microbiological growth in fuel being delivered to an aircraft is a reliable indication of failure of the fuel system cleanup equipment and personnel.

The fuel from an aircraft suspected of having microbiological contamination must not be defueled into a clean system. Once a fuel system is contaminated with microbiological growth, the organisms continue to multiply unless the system is thoroughly cleaned.

Emulsions

An emulsion is a liquid suspended in other liquids. There are two types of emulsions; water-in-fuel and fuel-in-water (inverse) emulsions.

The water-in-fuel emulsion is the most common of emulsions found by fuel handlers. It appears as a light-to-heavy cloud in the fuel. (See the second and third bottles of fuel shown in fig. 3-2.) This type of emulsion may break down and settle to the bottom of the sample container at any time ranging from a few minutes to a week, depending on the nature of the emulsion.

Surfactants

Surfactant is a contraction of the words *surface active agent*. A surface active agent is a substance that causes a marked reduction in the interfacial tension of liquids. A surfactant in fuel causes the fuel and water to mix more easily and become much harder to separate. Surfactants disperse both water and dirt in fuel and in some cases form very stable emulsions or slimes.

The surfactants that appear in jet fuels are usually the sulfonates or naphthenates of sodium. These can be present as naturally occurring materials in the crude oil or as residual refinery treating materials. Refinery processing must be such that it removes all traces of these materials, or poor quality fuel results.

Many other materials are also surface active. The list includes common household detergents, cleaning compounds used to clean fuel storage tanks and earner vehicles, greases used to lubricate valves, and corrosion inhibitors used in petroleum products to reduce rust in pipelines and tanks.

Surfactants in jet fuel can be a major problem. These materials accumulate and concentrate in the coalescer elements of filter/separators, destroying the ability of the elements to coalesce and remove water from fuel. Concentrations of less than 1 ppm of a surfactant in jet fuel have been known to cause malfunctioning of coalescer elements. Elements so affected pass free water and suspended particulate matter.

Surfactants are also associated with microbiological slime growths. It is not necessary that surfactants be present for microorganisms to flourish, but they promote luxuriant growth by aiding the mixing and emulsifying of fuel and water. Microorganisms need free water to multiply and grow. Surfactants help them to get it.

The problem with surfactants is that they quite often are not detected in jet fuels until after they have "poisoned" filter/separators, which in turn have allowed water and/or slime to be delivered to aircraft. There are laboratory tests for surfactants in fuel, but as yet there are no accurate field tests. However, a surfactant problem can usually be detected by one or more of the following observations:

1. Dark, red-brown, or black water in filter/ separator sump drains, refueler sump drains, or pipeline low-point drains
2. Excess quantities of dirt and/or free water in the fuel at dispensing points or downstream of filter/separators
3. Storage tanks not yielding a clear, bright fuel after prescribed settling times
4. Dark or black water and/or slime in drawoffs from storage tank bottoms
5. Triggering of fuel monitors in delivery systems, if installed

No two cases of surfactant contamination in fuel systems are exactly alike. However, some general measures can be used to correct and control this type of contamination. Some of these procedures are as follows:

1. Change monitor fuses.
2. Change filter/separator elements and clean out filter/separator cases.

3. Clean out pipelines.
4. Remove contaminated tanks from service and clean them thoroughly.
5. Recirculate fuel and return it to the system upstream of as many filter/separators as possible.
6. Investigate the source of contamination and eliminate it. Notify cognizant Military Inspection Service and Navy Fuel Supply Office if fuel is contaminated on receipt.

Commingling

The inadvertent mixing of two or more different fuels is known as commingling. Most hydrocarbon products (greases, oils, alcohols, and so on.) are readily capable of mixing with other hydrocarbon products and cannot be separated by mechanical means such as settling, filtering, or centrifuging. A fuel that has been contaminated by commingling with another petroleum product is extremely dangerous whether in storage or in use, because there may be no apparent visual or odor change.

This type of contamination is usually caused by carelessness or a misunderstanding of the operations of a fuel system. Most fuel systems are segregated from each other and from other types of fuel systems; but in some cases the piping of one fuel system may be interconnected with another system through valves, blanks, or flanges. The inadvertent opening of a wrong valve can result in commingling the two different products.

In other instances, fuel may be pumped into a tank that has contained another product without the tank being properly cleaned. The small amount of the other product may be enough to contaminate the fuel.

JP-5 contaminated with other jet fuels or gasoline must not be stored aboard aircraft carriers unless a laboratory test indicates that the flash point is within the allowable limits of the specifications.

Because of the problem in detecting commingled fuels, you must be careful where two different fuels are handled in close association.

INSPECTION OF FUEL

The fuel systems and mobile refuelers now in use by the Navy are designed to deliver an acceptable uncontaminated fuel safely into the tanks of an aircraft when they are properly operated. To ensure that this fueling equipment is working properly and is being operated properly, samples of the fuel must be taken at several points and after each step in the operation.

SAMPLES

A sample is a small part of a quantity of a fuel representative of the quality or condition of the total quantity of that fuel, suitable for visual or chemical examination.

All ABFs must know the procedures for drawing of samples and examining them for visual contamination. A sample must be taken in such a manner and from such a location that the sample will be a true representative of the fuel sampled.

Many types of samples and sampling methods are used in the inspection of fuels. The four most common ones are discussed here.

Composite Sample

A single tank composite sample is a blend of samples taken from the upper, middle, and lower levels of a tank's contents. A multiple tank composite sample is a blend of individual all-levels samples from each of the tanks that contain the same type of product being sampled. These samples are in proportion to the volume of the product in each tank.

All-Levels Sample

This sample is one obtained by submerging a closed sampler (thief) to a point as near as possible to the drawoff level, then opening the sampler and raising it at such a rate that it is nearly but not quite full as it emerges from the liquid.

Line Sample

A line sample is one taken from a pipeline or hose at or near the discharge point before commencing delivery and during the first few minutes of pumping. This sample is taken to give an initial visual identification of the fuel.

Representative Sample

This type of sample is used for packaged stocks of fuel. One container from a large stock of packaged fuel when all are of the same age and grade may be selected as a representative of the entire stock. When the containers of fuel are small and suitable for shipment, a container of fuel is taken as the sample without its being opened. For drums of fuel, the sample is drawn from one drum.

SAMPLING PROCEDURES

Correct sampling and labeling of petroleum products is as important to fuels inspection as correct testing. Improper containers of poorly drawn samples or incorrectly identified samples can cause laboratory results to be meaningless or, worse, misleading.

Some cardinal rules in sampling follow:

1. The sampler's hands or gloves must be clean.
2. A sample container must be meticulously clean. It should be thoroughly cleaned and inspected before use. Before a sample is taken, the clean container should be rinsed and flushed three times with the fuel being sampled.
3. All samples must be representative of the product being sampled. Any sample of fuel being delivered to an aircraft should be taken from the fueling nozzle and during actual fueling operations. A sample taken to test a fixed filter/separator should be taken at the filter discharge.
4. Each sample should be capped promptly with an approved cap. Do not use sealing wax, rubber gaskets, or caps with wax seals.
5. Each sample should be drawn from a connection in a vertical pipe run where practical. If it must be drawn from a horizontal run, the connection should be halfway between the top and the bottom of the pipe.
6. A sample should be taken with the system operating at a normal and steady flow rate, if possible.
7. To prevent leakage due to increased pressure caused by thermal expansion of the product, do not fill any container above 90 percent capacity.
8. A container such as a drum should be sampled with a thief sampler and not by tilting. Be careful to remove all foreign matter from the area before the plug is removed from the drum.
9. For nozzle samples, the sample should be taken from the overwing nozzle during or immediately after the fueling of an aircraft. A pressure nozzle has a Gammon sample connection that allows a sample to be taken while the aircraft is being fueled.

Sizes of Samples

The minimum size sample container for taking samples of fuel is 1 quart. This size sample is of sufficient size for sediment, water, and flash point tests only. For other types of tests, the sample submitted should be at least 1 gallon.

A sample container for sediment and water tests must always be glass with a nonmetallic top.

Identification of Samples

Proper identification and accurate records of samples are necessary so the test results may be correlated with the samples submitted.

The following should be used as a guide for sample identification:

1. Sample serial number (activity number).
2. Type fuel (JP-5, MOGAS, and so on.).
3. Name and location of activity.
4. Date sample taken.
5. Approximate time the sample was taken.
6. Location of sample point (nozzle sample, filter number, tank number, refueler number, and so on.).
7. Quantity of material represented, if applicable.
8. Classification of sample (routine or special—see the following section).
9. Name of person taking sample.
10. Tests required.
11. Remarks.

Sample Classification

Samples are classified as either ROUTINE or SPECIAL. ROUTINE samples are taken when no fuel problems or aircraft problems attributable to fuel are known or suspected. An example is the periodic sampling taken as a part of a quality surveillance program. These samples should be tested for sediment and water, and for JP-5, flash point. SPECIAL samples are submitted for test because the quality of the fuel is suspected, either as the result of aircraft malfunctions or other information. SPECIAL samples should have the highest priority in handling, testing, and reporting.

Container

The container for drawing a visual sample should be at least 1 quart in size, round, and made of clear glass. The top should be as large as possible to aid in drawing the sample without spilling the fuel. The cleaning procedures previously described under sampling procedures should always be carried out when you are taking a visual sample.

Shipping Instructions

Samples are to be forwarded to appropriate testing laboratories by the most expeditious means. Wherever feasible, samples should be delivered directly to the laboratory by hand. Samples in amounts up to 10 gallons may be shipped via Railway Express.

Four 1-quart samples or a 1-gallon sample (1 gallon maximum) of fuel may be air shipped via military aircraft when packed according to NAVAIR 15-03-500 (USAF AMF 71-4), which further indicates that fuel samples may be transported on passenger-carrying aircraft.

Visual Inspection Procedures

Since very small percentages of water or foreign matter can cause trouble, the sampling and inspection of fuel must be done carefully. Proceed as follows:

1. The first check you make is to visually inspect the color of the sample. The color of the sample must agree with the color for the grade of fuel that the system is supposed to carry. The color of the fuel may have changed because the fuel has been mixed with another petroleum product. A definite yellow cast or darkening of color in gasoline may be caused by lubricating oil, diesel oil, or jet fuels. Lubricating oil and diesel fuel also can cause a change in color in jet fuels. Since the percentage of another petroleum product in a fuel may be so small that it cannot be detected visually, yet can make it unacceptable for use, no off-color fuel should be used until an analysis is made to determine its usability.

2. The second check of the sample should be for water. The sample should be free of any cloudiness. See the first sample illustrated in figure 3-3 for an example of acceptable fuel for this visual check. The sample must be clear enough that newsprint can be read through a 1-quart sample. If the fuel is cloudy and the cloud



Figure 3-3.—Degrees of cloudiness in JP-5. The left sample is clean and bright and is the only acceptable fuel for aircraft.

disappears at the bottom, air is present. If the cloud disappears at the top, water is present. If the cloud does not begin clearing in a few minutes, it is due to entrained water or very fine particulate matter. Do NOT use any fuel containing a cloud that does not disappear in a few minutes after it is drawn or use a fuel containing any visible water to fuel an aircraft.

3. The third check should be for sediment. Swirl the sample so a vortex is formed. All sediment that has settled accumulates on the bottom of the bottle directly beneath the vortex. At the most, the total sediment should be only a point or spot of silt. In a quart sample, the sediment should be no more than a slight smudge if picked up on a fingertip.

Coarse contamination can be detected visually. Sediment in the fuel is visible when the particles are 40 microns or larger. Groups of particles less than 5 microns in size may be seen in the fuel when viewed at a right angle to a strong light. When a fuel sample is being inspected, it should be swirled and allowed to settle for a few moments. The coarse particles settle to the bottom center of the bottle and collect in a group. Any sediment that can be seen is too much for aircraft use.

The AEL Free Water Detector should be used to determine the presence of free water above the allowable limit (for aircraft) of 5 ppm. Free water at this level of contamination may or may not be visible to the naked eye.

Fuel that is contaminated by commingling with another petroleum product is hard to detect visually. In gasoline, if the percentage of the other petroleum is fairly high, there may be a color change. JP-5 contaminated by JP-4, or vice versa, can be detected by a test for flash point and a laboratory test for distillation.

Results

If any contamination is discovered during the visual inspection procedure, stop the fueling operation immediately and notify the pilot of the aircraft, the fuels officer, or other designated person in charge as to the condition of the fuel.

Action

A contaminated sample should be suitably tagged and retained until it is determined that a laboratory analysis of the sample is not required. When any contamination is found, another sample should be

taken, preferably in a new sample container. Take care to ensure that the container is thoroughly clean before drawing the sample. Once contamination is found and the system placed out of use, a check must be made for the source and cause of the contamination and the cause corrected before the system is placed in use again. The type of contamination discovered usually gives a clue to the source and cause. Some of these indications are as follows:

1. Mixed or commingled fuels—The valve or blank flange is open between two different systems or there is a leak through a bulkhead where two tanks containing different fuels are adjacent.

2. Water—The filter/separator elements are ruptured or contaminated. Large amounts of water also indicate that the filter/separator float control valve was not operating and water stripping operations for the service tanks were inadequately performed.

3. Sediment and microbiological growth—The filter/separator elements are ruptured or contaminated. Large amounts of sediment or microbiological growth also would indicate that the storage tanks and service tanks need cleaning.

CONTAMINATED FUEL DETECTING EQUIPMENT

The equipment used in the lab is portable but only to the extent that it may be moved from one area to another. You cannot carry it around with you for daily use. It is better to describe it as movable even though PMS electrical safety checks require it to be listed as portable equipment.

A good fuels lab has the following facilities: good ventilation, hot and cold water to wash bottles, and a bottle drying rack. Bottle drying racks can be bought commercially, but most are constructed locally. See figure 3-4.

The combined contaminated fuel detector (CCFD) is a single unit that contains both the AEL Mk I and AEL Mk III. Many stations and ships have both the CCFD and the single units. The AEL Mk II is the same as the Mk I except it has a carrying handle,

The AEL Mk I and Mk II are used to measure water contamination, and the AEL Mk III is used for sediment detection. The closed cup flash-point tester is used to determine the flash point of jet fuels. The flash-point tester is not to be used to test gasoline products. The refractometer indicates the amount of

fuel system icing inhibitor (FSII) present in fuels, and the hydrometer is used to measure the specific gravity.

The equipment in the lab is very good for what it was designed to do. It is also very expensive. The CCFD costs about \$5000. The closed cup flash-point tester costs about \$1000. Take care of "your" equipment and it will last a long time. Also, remember the equipment is only as good as the people who use it.

We are now going to go step-by-step through the operation and calibration of the equipment used in the Aviation Fuels Lab.

First, you should understand that the CCFD is a newer model of the AEL Mk III with an AEL Mk I built in the same case and that the CCFD gives the sediment reading by digital display. The theory and operation of the CCFD are the same as for the individual units.

With any of the units, for initial startup or after moving them from one space to another, you **MUST** allow adequate time for the unit to reach the same temperature as the space in which it is to be used. This is **IMPORTANT** so any condensation that may form inside the machines will not affect your readings.



Figure 3-4.—Bottle washer and drying rack.

Also, after any maintenance on the AEL Mk III, calibration is REQUIRED.

CONTAMINATED FUEL DETECTOR AEL MK III (CFD)

The contaminated fuel detector is a portable self-contained unit. This instrument is used to determine the quantity of solid contamination present in aircraft fuels.

The detector consists of a fuel sample container, a fuel filtration system employing millipore filters, and a light transmission system for determining the quantity of solid contaminants on the millipore filters. All components necessary for filtration and measuring transmitted light are incorporated into one serviceable package. See figure 3-5.

The level of fuel contamination is measured by using the principle of light transmission through a millipore filter. A sample of fuel is filtered through the millipore membrane.

The millipore filters have 0.65 micron pores. Contaminating particles are retained on the surface of the membrane. If a beam of light is directed

through the membrane, part of the light is absorbed by particles of solid contaminants.

To increase accuracy, and to eliminate any fuel color effect, two millipore filters are used in series. The first filter traps the solid contaminants, plus fuel color effect; the second filter is subjected to clean fuel and retains only the fuel color effect. Thus, the difference between light transmission through the two filters depends only on the amount of solid contamination. By measuring the difference between the amount of light transmitted through the contaminated membrane and the clear membrane, it is possible to establish the level of contamination in fuel.

The steps for preparation and use of the AEL Mk 111 are as follows:

1. Remove the power cable from inside the instrument cover and connect it to a suitable source of 110-volt, 60-hertz power. The power cable contains a ground wire to ground the instrument.
2. Turn the light switch on. The light system should be allowed to warm up for 2 to 3 minutes before use.

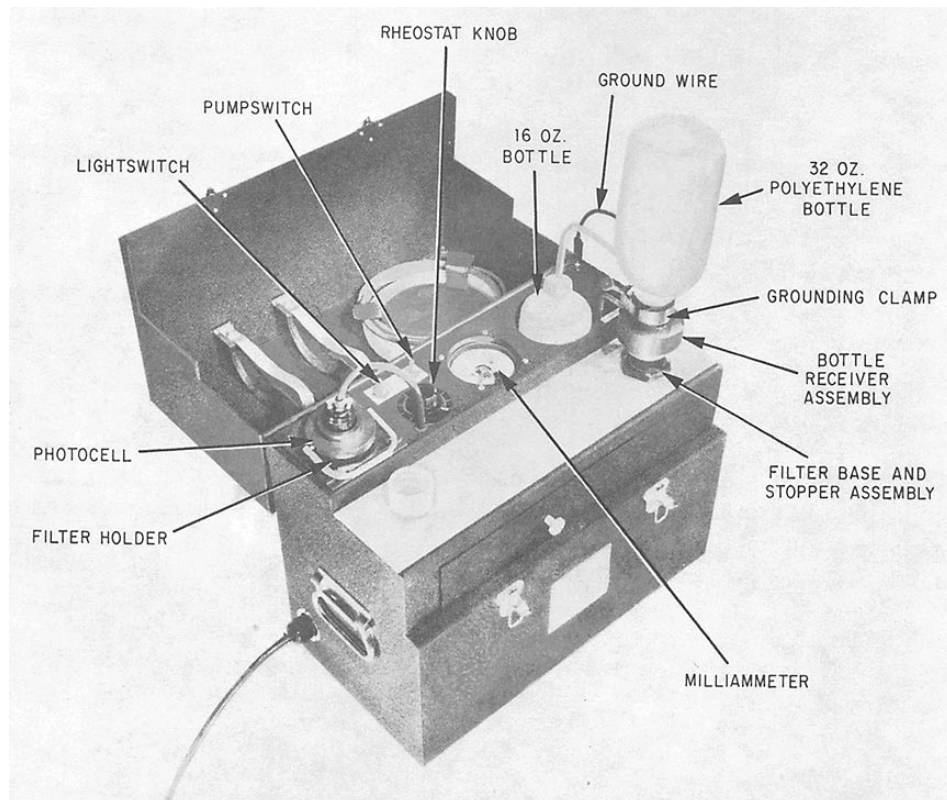


Figure 3-5.—AEL Mk III (front view).

3. Make sure the fuel flask is empty and the drain cock is closed.

4. The filter base and bottle receiver assembly located in the lid should be disassembled into its two components. The section with the rubber stopper is the filter base and should be inserted into the opening in the fuel flask.

5. The millipore filter is a paper-thin white membrane. Place two millipore filters right side up on the filter base. These filters should be handled only with forceps, and only by their edges. *Do not handle the filters with your fingers.* Reassemble the filter base and bottle receiver assembly. Rotate the locking ring carefully to prevent damage to the filters.

6. Fill the 32-ounce polyethylene bottle to the 800 milliliter (ml) mark with fuel. Place the filter base and bottle receiver over the top of the bottle.

7. Make sure that the drain cock valve is closed or fuel will be pulled out of the drain tank and flood the machine.

8. Insert the ground wire attached to the filter base and bottle receiver assembly into the opening provided. Turn on the pump switch; a vacuum pump is connected to the fuel flask to speed up filtration.

9. Insert the entire assembly (filter base, bottle receiver, and fuel sample bottle) into the fuel flask. During the filtration cycle, the fuel in the sample bottle should be agitated occasionally by gently shaking the bottle to ensure that any contaminants are washed down and not lodged on the inside surface of the bottle. If the sample bottle tends to collapse, gently loosen the bottle in the bottle holder by tilting it slightly during the filtration cycle. After all the fuel has passed through the filters, stop the pump.

NOTE

Before measuring the contamination on the filters, you should clean the photocell and light window.

10. OPEN the drain cock valve and drain the fuel from the flask through the tygon tubing into a suitable container. When the flask is empty, CLOSE the drain cock valve.

11. With the filter out of the receptacle, ensure the photocell is in the measuring position.

12. Adjust the rheostat knob for a light intensity reading of 0.6 on the milliammeter.

13. Using forceps, pick up the contaminated filter top and wet it with clean (refiltered) fuel. Ensure the entire filter becomes wet with fuel. This prefiltered fuel is called wetting fuel. It is used to keep the entire millipore filter wet. It is NOT used to wash contamination off the millipore filter. By keeping the entire filter wet you do not get a change of reading from the dry areas to the wet.

NOTE

WETTING FUEL is produced by rerunning the same sample through millipore filters several times. Although no exact number of times is required to rerun the sample to make wetting fuel, it is recommended that the sample be rerun until the light transmission readings for both filters are identical.

14. Lift the photocell (or slide out the plate on newer machines) and, using forceps, place the contaminated filter in the receptacle.

NOTE

The CCFD or DIGITAL reading instruments have a slide plate that you put the filters on and slide under the photocell. The photocell does not move. When you use this design, be careful when putting the filter in the slide and sliding it under the photocell. If you do not put the filter in the slide properly, the filter may come off inside the machine.

15. Swing the photocell (or slide in the plate) back into measuring position and ensure it is fully seated.

16. Record the reading on the milliammeter; this reading is in thousandths of a milliamp.

17. Remove the filter. Check to see that the meter still reads 0.6 milliamperes; if not, adjust the meter to 0.6.

18. Repeat steps 13 through 17, using the clean (bottom) filter.

19. Subtract the meter reading obtained from the contaminated filter from the meter reading obtained

from the clean filter. This change in reading value is used with the calibration chart in figure 3-6.

20. Find this value on the left of the chart, then move horizontally until the reference line is intersected. Read vertically at either the top or bottom of the chart to determine the amount of contamination in either milligrams per gallon or in milligrams per liter.

NOTE

Each contaminated fuel detector has its own calibration chart that is marked with the same serial number as the unit.

You should recognize that this instrument is only a secondary standard and does not replace the requirements for periodic laboratory analysis; it supplements the laboratory analysis. Extensive field tests have demonstrated that the calibration chart with this unit is valid for most fuel samples. However, there are occasional samples that do not fit the normal pattern. It may become necessary to establish a new or modified calibration chart in a few unusual cases where the contaminants in a particular

system do not follow normal patterns. Duplicate samples sent to the laboratory for gravimetric analysis can give a cross-check on the instrument and quickly pinpoint these unusual situations.

Light Intensity Adjustments

If insufficient adjustment is available to obtain a reading of 0.60 milliamps on the meter as outlined in step 12, proceed as follows: Set the rheostat at midscale and note the meter reading with the light on and the photocell in the measuring position, and no filter in the receptacle. Unplug the instrument and open the back. Loosen the light bulb holder slightly. See figure 3-7. If the meter reads below 0.60 milliamps, slide the bulb holder up. If the meter reads over 0.60 milliamps, slide the bulb holder down. The filament of the light bulb should be horizontal after the change is made. Temporarily close the case, plug in the instrument, turn on the light, and check the meter reading. It is not necessary to obtain an exact 0.60 reading by adjustment of the light bulb because final adjustments will be made by use of the rheostat. When a suitable position for the light bulb has been found that will permit adequate adjustment by the rheostat,

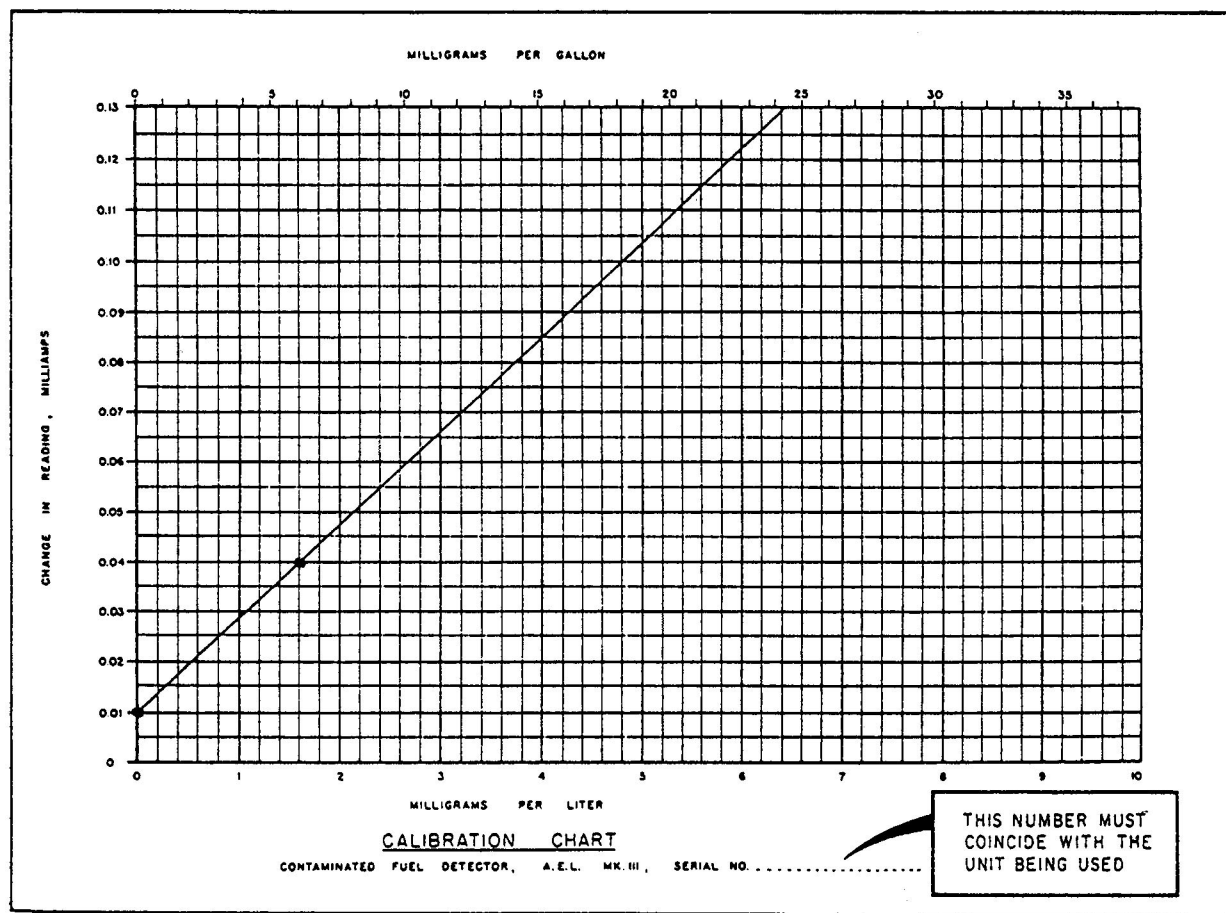


Figure 3-6.—Calibration chart.

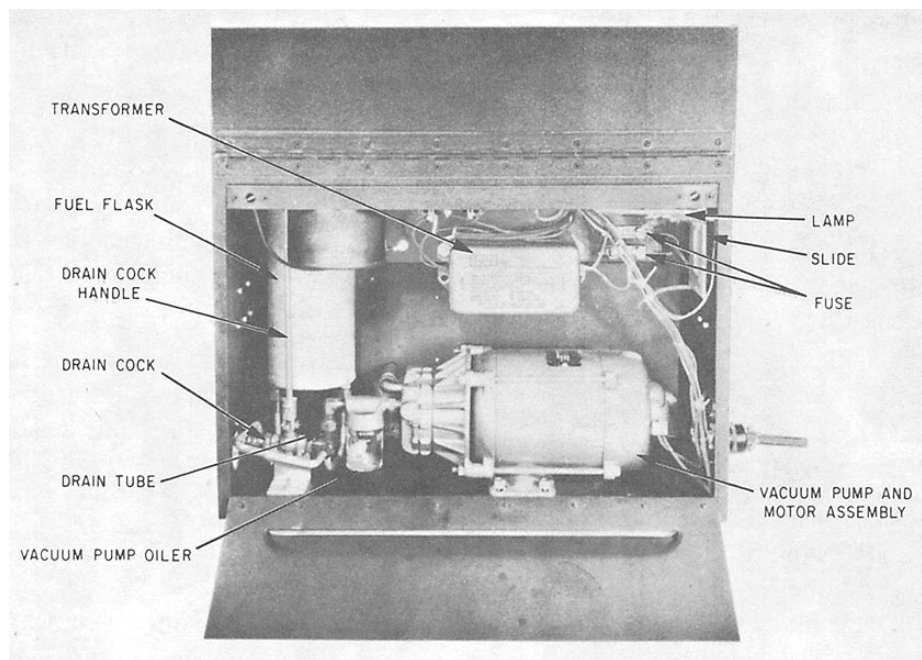


Figure 3-7.—AEL Mk III (rear view).

retighten the nuts on the bulb holder. Refasten the back of the instrument.

Calibrating the AEL MK III

The AEL Mk III comes with 2 WRATTEN calibration filters that are wrapped in silver foil. A Wratten calibration filter set is a pair of filters with a known contamination value. The filters must be kept in their silver foil wrappers so dust does not affect the readings you get.

The reason you have to calibrate an AEL Mk III is that you get wear on the photovoltaic cell, which will give you improper readings if not constantly checked.

NOTE

Calibrate quarterly or when a part is replaced according to PMS.

When you handle the filters, use FORCEPS. The area of contact should be within 1/4 inch of the edge of the filter to avoid damage to the filter's surface. The calibration should be done in the following manner:

1. Turn on the light and let it warm up for at least 3 minutes.

2. Adjust the light intensity, using the rheostat knob, until the milliammeter scale reads 0.6.

3. Pickup one Wratten filter, using the forceps. Lift the photocell (or slide out the plate) and insert the filter into the receptacle. Replace the photocell (or slide in the plate) and record the milliammeter reading in the log book.

4. After logging your results, remove the Wratten filter and put it back into the foil wrapper.

5. Readjust the rheostat, if the milliammeter reading is not 0.6.

6. Repeat steps 3 and 4 with the second Wratten filter.

7. To obtain calibration point, subtract the lower of the two milliammeter readings from the higher reading. This difference is plotted on the calibration chart versus the weight of contaminant per liter given for the set of Wratten filters. A second point is plotted at 0 milligrams per liter and 0.01 milliamps change in light reading. Example (fig. 3-6):

- a. Filter contamination factor = 1.6 milligrams per liter.

- b. Difference between Wratten filters = 0.04 milliamps.

- c. Plot this point with the calibration chart.

- d. Plot second point where 0 milligrams per liter and 0.01 milliamps BISECT.

e. Now draw a line connecting the two.

f. Date the calibration chart so as not to confuse it with the previous chart.

NOTE

On the back of the chart it is a good practice to put the serial number of the Wratten filters used and on the front it is required to have the machine serial number.

FREE WATER DETECTOR (AEL MK I AND AEL MK II)

The free water detector (fig. 3-8) was developed to measure accurately the amount of free water in fuels. This detector is used with the Contaminated Fuel Detector in the normal fuel inspection and surveillance programs; the test should be executed as soon as possible following the sampling.

The free water detector consists of an ultraviolet light source, a set of standards indicating 0, 5, 10, and 20 ppm, and water detector pads.

A test sample of fuel is passed through a chemically treated filter pad in the filter holder of the Mk III detector. The chemical on the pad is sensitive to any free water in the fuel. If water is in the fuel, the pad produces a visible fluorescent pattern when it is placed under an ultraviolet light.

Instructions for using the AEL free water detector are as follows:

1. Mark the polyethylene bottle 3 1/4 inches from the bottom. When the bottle is filled to this mark, a 500-ml sample will be obtained.

2. Fill the polyethylene sample bottle to the 500-ml mark with fuel to be tested.

3. Open a free water detector envelope and place the detector pad, orange side up, on the contaminated fuel detector base. Attach the bottle receiver to the filter base and plug in the ground wire jack.

CAUTION

Handle the detector pad with forceps only. Do not touch the pad with your fingers or it becomes contaminated before you even start the test.

4. Check to see that the contaminated fuel detector fuel flask is empty and the drain cock closed.

5. Shake the bottle containing the 500-ml fuel sample vigorously for approximately 30 seconds.

6. Immediately after shaking, turn the vacuum pump on, unscrew the bottle cap, place the bottle receiver firmly over the end of the bottle, and insert the filter over the end of the bottle. Then insert the filter base into the contaminated fuel detector. This step should be done in as short a time as possible to keep any free water in suspension.

7. After the 500-ml sample has passed through the detector pad, turn off the vacuum pump IMMEDIATELY, and remove the bottle and bottle receiver.

NOTE

DO NOT continue to draw air through the detector pad. If the moisture in the air is drawn through the pad, you get an incorrect reading.

8. Remove the pad from the filter base with forceps and place it (orange side up) in the free water detector slide depression.

9. Light the ultraviolet bulb in the free water detector by holding the light switch in the ON position, and insert the slide containing the test pad.

10. Look through the view port of the box and compare the brightness of the test pad with that of the set of standards to determine the amount of free water. Free water content is indicated in ppm by the numbers located directly above the standards.

11. If the result is over 20 ppm, take a new sample of one-half the standard sample and double the answer.

NOTE

The standards card in the free water detector must be replaced after 6 months of use according to PMS.

The standards in the box when received should be marked with the date on which the detector is first put into use. The reason for replacing the standards every 6 months is that the fluorescent inks in the pads deteriorate after prolonged exposure to ultraviolet light.

To replace the ultraviolet bulb, turn the used bulb one-quarter turn and lift it out of the fluorescent lamp

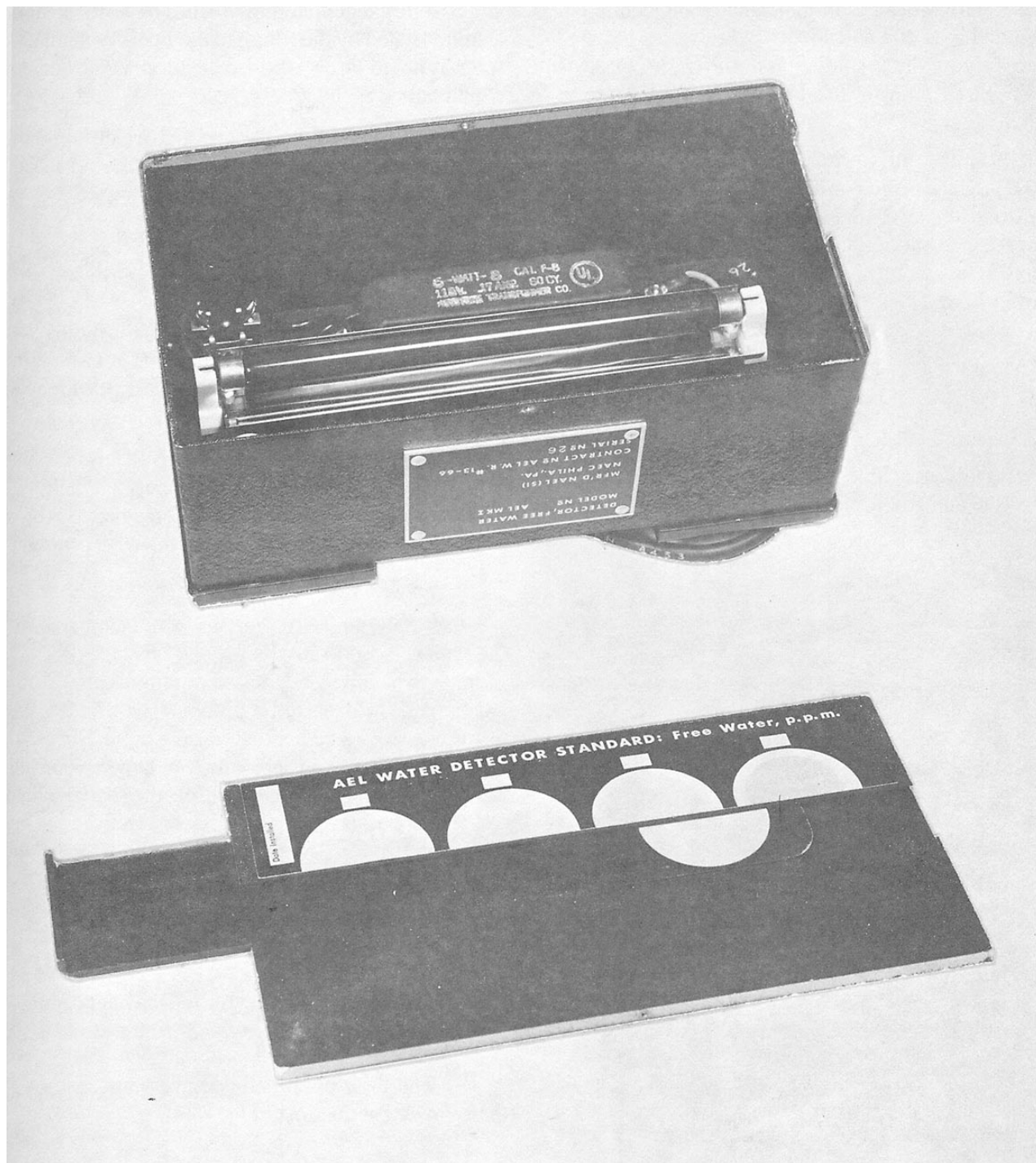


Figure 3-8.—Free water detector (light source and standards).

holder. To insert a new bulb, rotate it one-quarter turn until it is locked in place. To replace the lamp starter, twist it clockwise until the starter is released, then put the new starter back in and turn it counterclockwise until it cannot be turned any more. **DO NOT FORCE THE BULB OR STARTER** during removal or installation.

ELECTRIC PENSKEY-MARTENS CLOSED CUP FLASH-POINT TESTER

The flash-point tester by Pensky-Martens is the standard Navywide flash-point tester. It is designed to test fuel with a flash point of 20° to 700°F, depending on the thermometer used. The ABF is to be concerned

with the thermometer with indicated readings that fall within the limits 20°-230°F.

First, you must understand the term **FLASH POINT**. Flash point is the **LOWEST** temperature at which the fuel gives off a **VAPOR** that can ignite.

In preparation for use, the flash-point tester (fig. 3-9) is to be placed on a level, steady surface. If the room where the tests are to be conducted is drafty, it is good practice (but not required) to surround the tester on three sides with a shield about 18 inches wide and 24 inches high. Do not make the shield out of wood or wood products.

To make the flash-point test, carry out the following steps:

1. As previously mentioned, do not test gasoline products in this machine. Thoroughly clean and dry all parts of the cup and its accessories before starting any test.

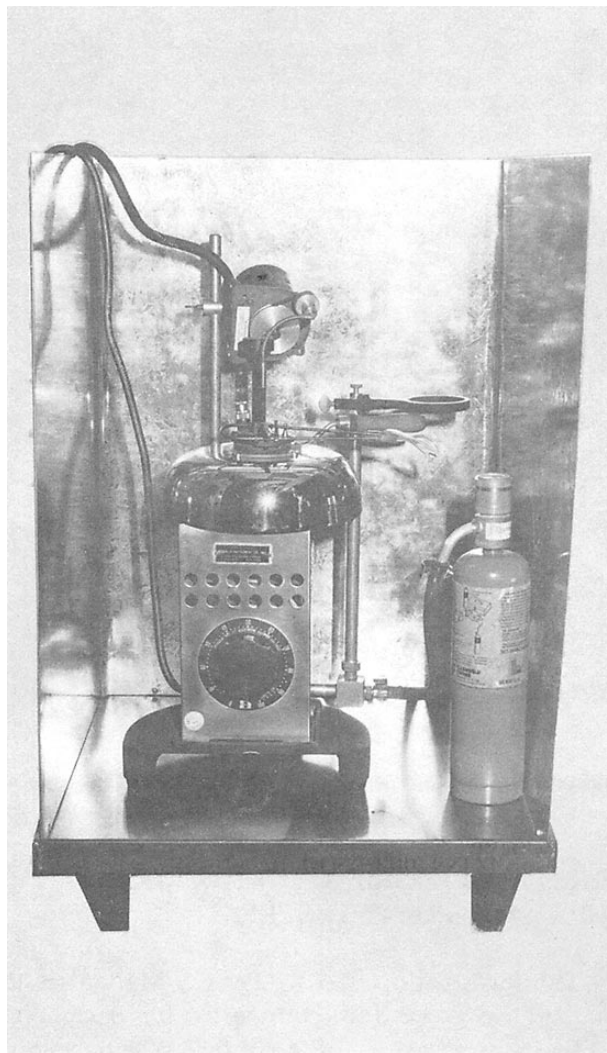


Figure 3-9.—Flash-point tester and metal shield.

2. Fill the cup with the fuel to be tested up to the level indicated by the filling mark. Fuel containing free water is not to be tested since the results you would get would not be accurate.

3. Place the lid on the cup and set the cup in the stove. Take special care because the lid has locating devices so it fits only one way.

4. Insert the thermometer. It is known that JP-5 fuel has a flash point of 140°F, so use the appropriate thermometer that has the range of 20°-230°F.

5. Light the test flame and adjust it by the valve screw on the burner block, so the flame has a 5/32-inch diameter—the same size as the bad provided for comparison.

6. Plug in the unit to a 115-volt power supply. Adjust the supply of heat by adjusting the dial on the powerstat until the temperature reading increases by not more than 11°F per minute nor less than 9°F per minute.

7. Connect the stirrer to the stirrer motor.

8. Apply the test flame when the temperature of the sample is 30° to 50°F below the expected flash point of the fuel, and thereafter in multiples of 2°F. For example, if the expected flash point is 140° (JP-5), the test flame should be applied starting at 90°F, then 92°, 94°, and so forth. You apply the test flame by operating the knurled hand knob that controls the shutter and test the flame burner. The flame is lowered in one-half second, left in the lowered position for 1 second, and quickly raised to its high position.

NOTE

Discontinue stirring during the application of the test flame.

9. The flash point is the temperature read on the thermometer at the time of the flash.

NOTE

The true flash must not be confused with the bluish halo that sometimes surrounds the test flame for the applications preceding the one that causes the actual flash.

REFRACTOMETER KIT

The refractometer kit (fig. 3-10) is used to determine the amount of fuel system icing inhibitor (FSII in jet fuels. Although it is small and made of plastic,

it is neither cheap nor more durable than other equipment in the quality surveillance laboratory. This little instrument costs about \$600, and the plastic can be scratched. Be careful when it is in use or in storage.

The name refractometer tells you how it works. By the prism on the front (fig. 3-11), light is refracted through the sample being tested onto the scale inside the refractometer.

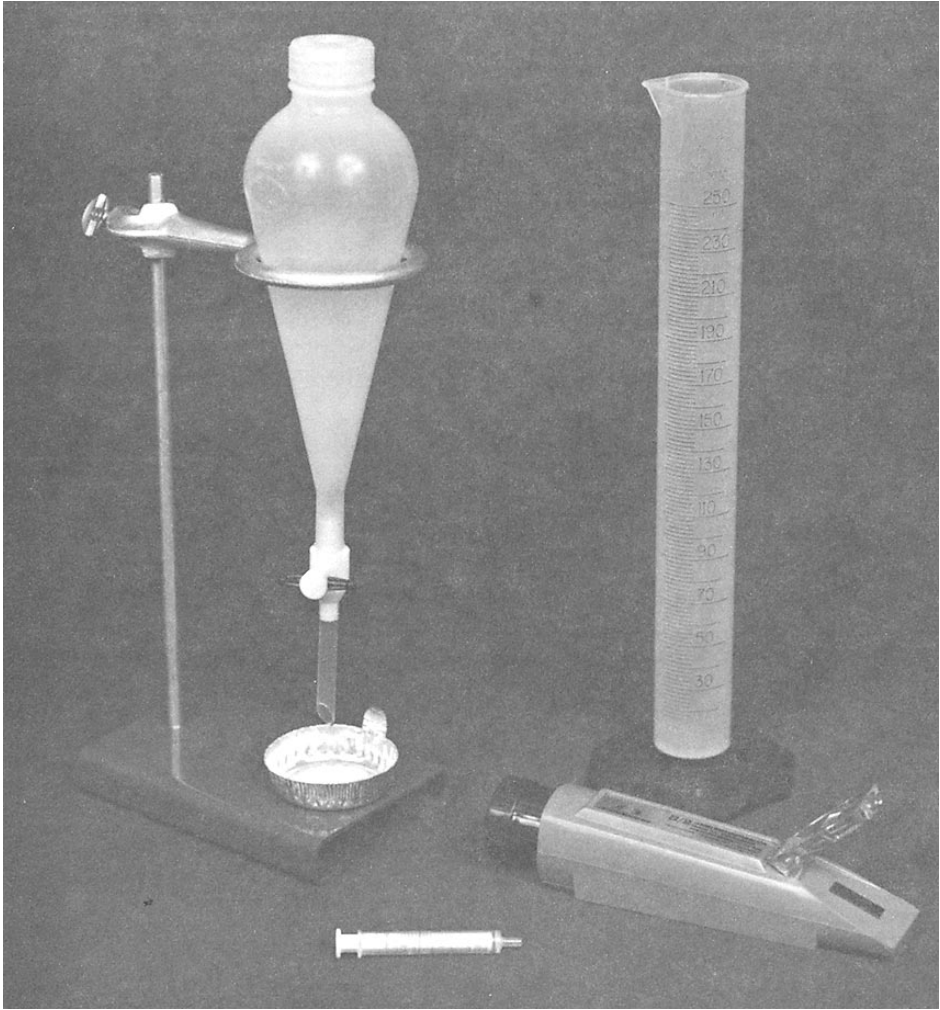


Figure 3-10.—Equipment in a refractometer kit.

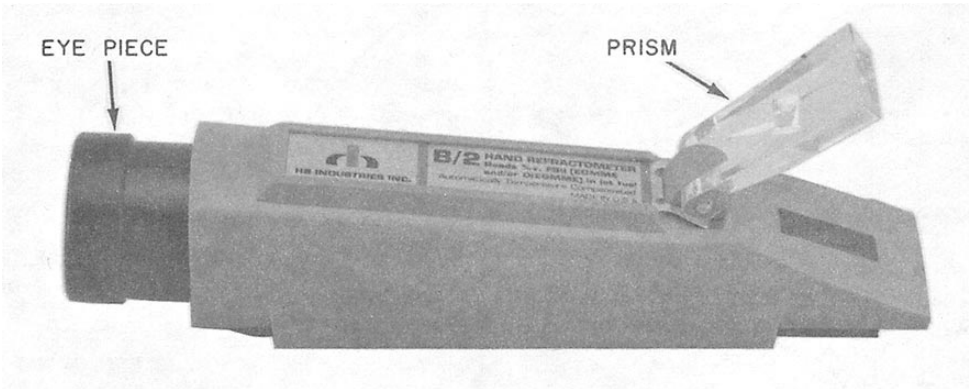


Figure 3-11.—Refractometer (top view).

Operation of the Refractometer

The refractometer is to be used in the quality surveillance lab, not on the flight deck or on the sponson. The light source can be a fluorescent or incandescent bulb, but the area must be well lighted. To use the instrument, perform the following steps:

1. Set up the ring stand assembly as shown in figure 3-10.
2. Use prescribed sampling procedures and take a 1-quart sample of the fuel to be tested in a clean sample bottle.
3. Half fill the aluminum dish with tap water.
4. Fill the graduated cylinder (fig. 3-10) and the separator funnel about one-third full with the fuel to be tested. Rinse the cylinder and funnel thoroughly to clear them of any foreign material and empty the contents.

5. Now fill the graduated cylinder with exactly 160 ml of the fuel sample.

6. Check to see if the drain cock on the separator funnel is closed. If not, close it and pour the 160 ml from the graduated cylinder into the separator-y funnel.

7. Using a piston pipet, add exactly 2 ml of water from the dish to the separator funnel. Place the capon the funnel and shake it for 3 minutes. Place the funnel in the ringstand as shown (fig. 3- 10).

8. Open the hinged plastic cover of the refractometer's window (fig. 3-11), make sure the window and cover are clean, and place several drops of water on it. Close the cover and look through the eyepiece. Observe the shadow line. Remove the black plastic rod from the bottom of the refractometer. Using the rod, adjust the setscrew (on the bottom of the refractometer) until the shadow line meets the zero line of the scale. See figures 3-12 and 3-13. By adjusting the set screw

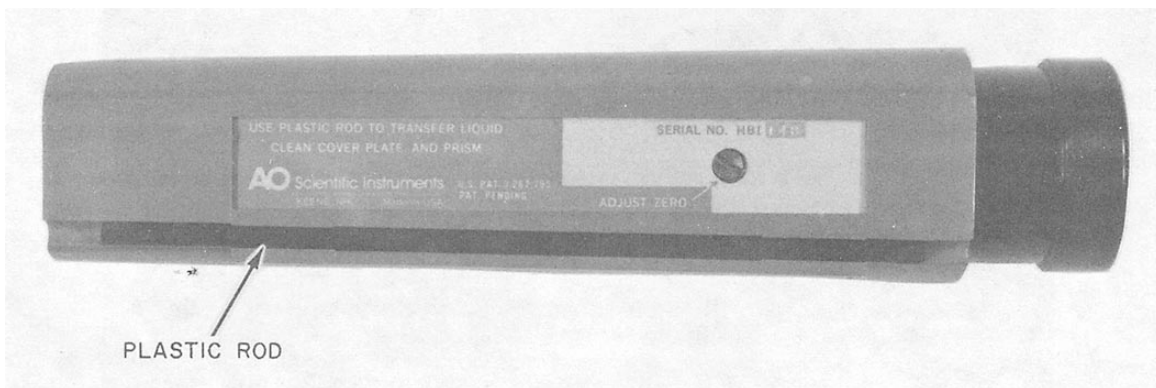


Figure 3-12.—Refractometer (side view).

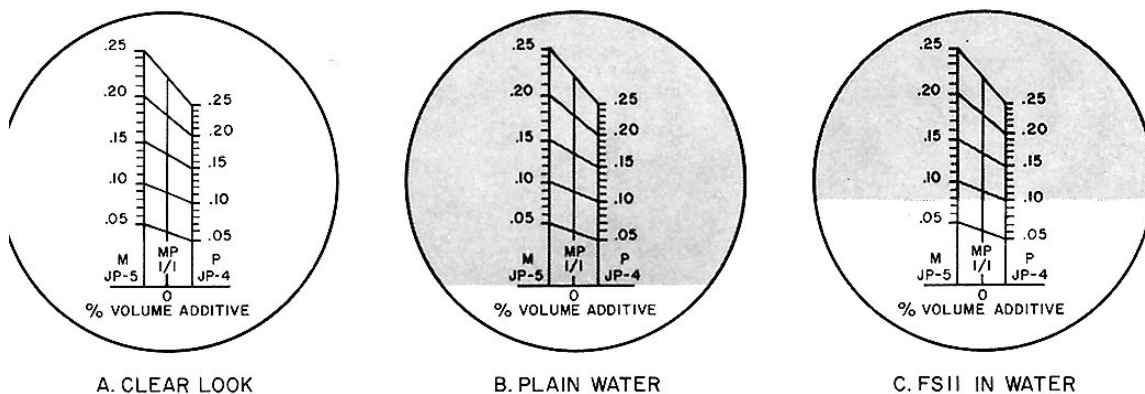


Figure 3-13.—Views through a refractometer.

until you read zero, you have made the refractometer ready to compare the FSII in the fuel to the scale inside the refractometer (fig. 3-13),

9. Open the plastic cover and wipe off the water from the window and cover.

10. Carefully turn the drain cock so several drops of liquid can trickle into a clean, dry aluminum dish.

11. Open the hinged plastic cover and place two or three drops of liquid from the funnel on the window. Close the cover. Look through the eyepiece and read the point where the shadow line is on the scale. This gives you the percentage of FSII by volume. Make a log entry of your finding. Your readings should read two digits to the right of the decimal point: for example, .08, .04, .06, etc. See figure 3-13.

12. Empty the funnel and properly dispose of the fuel. Clean the equipment with soap and water, and ensure the equipment is thoroughly clean by rinsing with water.

The minimum use level for USN and USMC aircraft that require FSII to prevent water-ice formation is 0.03 percent. Currently these aircraft are the S-3, US-3, and SH-60. All other USN and USMC aircraft do not require FSII and may use JP-5 or other approved fuel even if it does not contain FSII.

If the FSII level falls below the 0.03 percent limit, the appropriate Navy or Marine Corps squadron commanding officer of a squadron containing the above aircraft, or his/her designated representative shall be notified.

Transient (USAF, USA, and visiting foreign military aircraft) crewmembers and pilots will be notified of FSII levels of 0.07 percent or less.

Care and Maintenance of the Refractometer

You must use very special care in handling the refractometer when it is in use and when it is stored. A very strong possibility of damage exists if the prism is

bumped or the whole unit is dropped. When you clean the equipment, use a mild soap. NO abrasive POWDER is to be used, since it scratches the plastic. Do not submerge the unit when it is being cleaned. If you do submerge it, fluid may get inside and may affect future readings. As of now, no repair parts are available but you can contact the Naval Air Propulsion Center if an emergency arises.

HYDROMETER

When you use a hydrometer, handle it with care. It is glass and breaks easily. The hydrometer (fig. 3-14) is used to measure the specific gravity of petroleum products.

For standardization, all of your readings will be converted to 60°F. The American Petroleum Institute has developed a conversion scale from one temperature to another.

Using standard sample procedures, draw a sample. Pour enough fuel into a beaker to float the hydrometer. Take your reading on the scale inside the hydrometer at the surface of the fuel. Use the conversion chart to note the temperature of the fuel to correct the reading from the ambient fuel temperature to the specific gravity at 60°F.

QUALITY SURVEILLANCE LOG BOOKS

In a day's operation of the fuel lab on some ships and shore stations, it is common to handle over one hundred samples a day. To be able to keep track of the sample results and to maintain good records, a log book is required for all samples.

When you begin the log book, you should enter the starting date on the front cover. When the log is full, enter the ending date. This procedure will help you locate sample results from the collection of completed logs. Make your log entries in ink and use only one side of each page. If you write on both sides of the page, it

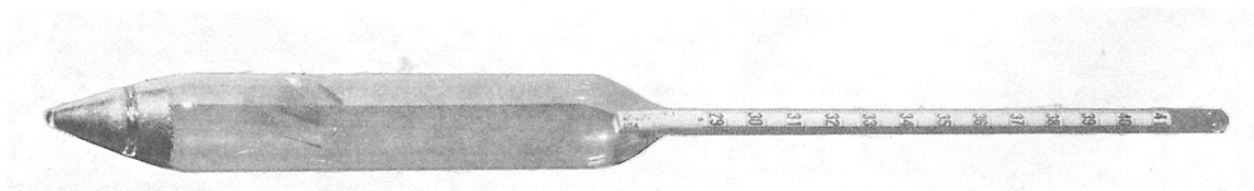


Figure 3-14.—Hydrometer.

